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AUTOMATED PREDICTION OF THUNDERSTORMS, DRIZZLE, RAIN, AND SHOWERS

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As part of the Techniques Development Laboratory's (TDL) effort to develop a complete computer-worded forecast for public weather, warm season (April-September) forecast equations for the probability of thunderstorms or severe weather, and also for the conditional probability of each of three types of liquid precipitation (i.e., drizzle, rain, and showers), have been derived.

The Model Output Statistics (MOS) approach (Glahn and Lowry, 1972) was used to relate predictand data from the National Climatic Center in Asheville, to forecasts from the PE (Shuman and Hovermale, 1968) and trajectory models (Reap, 1972). Potential predictors consisted of the variables related to formation of thunderstorms and precipitation as shown in Table 1. The amount of smoothing (5, 9, or 25 points), used to attempt to eliminate small scale noise, is also indicated on this table. In general, the amount of smoothing was a function of element, level, and projection. Individual station constants, as well as the sine and cosine of the day of the year, were also included as potential predictors. The data sample covered the period April through September of 1973.

Twelve-term, generalized operator equations were derived for projections of 18, 30, and 42 hours from 0000 GMT. Separate equations for the eastern and western sections of the United States (see Figure 1) were generated for each projection for the probability of thunderstorms. Since the likelihood of severe weather at any given hour is generally very low, the predictand

was obtained from 3-hourly surface observations during a 12-hour period centered at the nominal valid time. For instance, the predictand for the 18-hour forecast was given the value of one if a thunderstorm, squall, hail, or tornado occurred at any of the times 1200, 1500, 1800, 2100, or 0000 GMT; otherwise the predictand value was set equal to zero. Because of this treatment, the resulting "probabilities" should be viewed as "index values" of thunderstorm potential.

The eastern and western section thunderstorm probability equations for the 30-hour projection are shown in Tables 2 and 3 respectively. As indicated by the cumulative reduction of variances, the total-totals and K index stability parameter forecasts from the trajectory model are of greatest importance to both equations. Here all the predictors are binary in form. This means that a predictor is given a value of one if it is less than the threshold value; otherwise the value of the predictor is set to zero when used in the equation. The maximum and minimum probability values are also shown on the tables. The maximum probability is computed by assuming that all the predictors with positive coefficients are one, while all the predictors with negative coefficients are zero. The minimum value is obatined in the opposite manner. However, it may be that neither of these values will actually occur.

In contrast to the thunderstorm probability equations, the equations for the conditional probability of precipitation type (conditional on the occurrence of liquid precipitation) were derived for one region covering the entire conterminous United States. This was necessary due to the reduced sample size, since the data were stratified to include only those cases where measurable, liquid precipitation acutally occurred. Also, predictand data at only the valid time of each projection were used. In addition, the

three equations for drizzle, rain, and showers for any given projection all contain the same twelve predictors with differing regression coefficients, since it is desirable that for any given station, all three probability forecasts add to unity.

The precipitation type equations for the 30-hour forecasts from 0000 GMT are shown in Table 4. Useful predictors in this situation are the convective instability forecasts from the trajectory model, as well as PE model forecasts of mean relative humidity and 850 mb wind and temperature. The seasonal trend expressed by the cosine of the day of the year is also of importance. Here as before, all predictors are binary.

It is planned that daily forecasts of thunderstorm probability and conditional probability of precipitation type for each of 233 stations will be available for input to development of TDL's AFOS application package during the Summer of 1974.

REFERENCES

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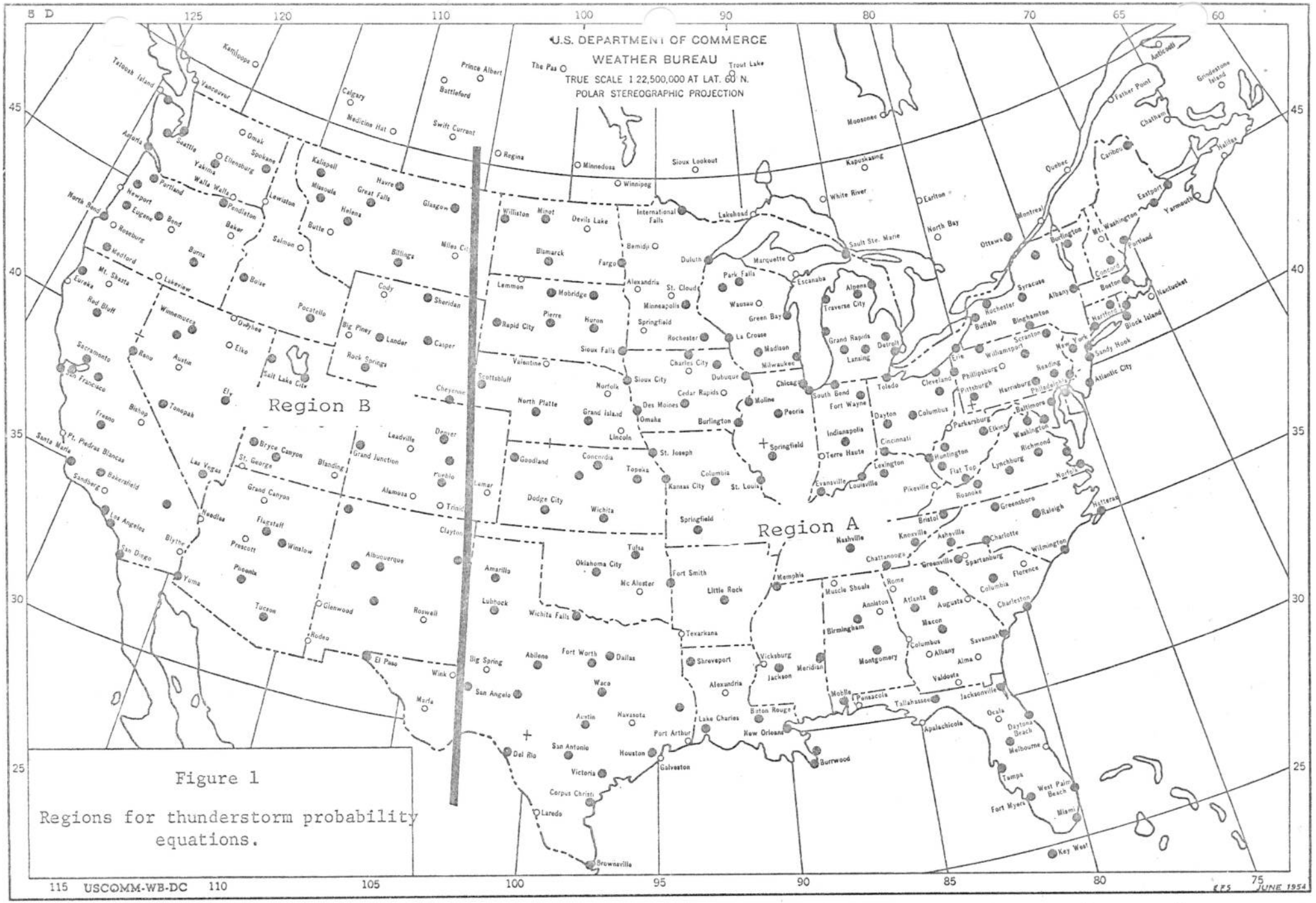

Figure 1

Regions for thunderstorm probability equations.

Table 1

Potential predictors for conditional probability of liquid precipitation and thunderstorm probability forecasting equations. The stars indicate that the field is smoothed by 5(*), 9(**), or 25 (***) points.

Predictors	Valid Times (Hours from Model Run Times)	Units
a) PE Model		
Mean Relative Humidity (1000 mb to 400 mb)	12, 12**, 18**, 24**, 30**, 36**, 42**, 42***, 48**, 48***	Percent
Precipitation Amount	12, 18, 24, 24**, 30, 30**, 36, 36**, 42**, 48**	M
G Index	18**, 24**, 36**, 48**	M
Vertical Velocity (650 mb)	24**, 36**, 48**	MB x Sec^{-1}
Constant Pressure Height (850 mb)	12, 18, 24*, 36*, 48*	M
Temperature (1000 mb, 700 mb, 500 mb)	24**, 36**, 48**	Deg K
Temperature (850 mb)	18**, 24**, 36**, 48**	Deg K
U Wind, V Wind (Boundary Layer)	12, 12**, 18**, 24**, 36**, 48**	M x Sec^{-1}
U Wind, V Wind (850 mb)	12*, 24**, 36**, 48**	M x Sec^{-1}
b) Trajectory Model		
Surface 12-hour Precipitation Amount	24, 24**	M
700 mb-Surface Convective Instability	24**	Deg K
700 mb Net Vertical Displacement	24, 24**	MB
K Index	24**	None
Total Totals Index	24**	None
850 mb Temperature minus 850 mb Dew Point	24**	Deg K
Surface Temperature	24**	Deg K
Surface Dew Point	24**	Deg K
c) Other Predictors		
Sine and Cosine (Day of the Year)		None
Station Elevation		M
Station Latitude		Deg
Station Longitude		Deg

Table 2

Probability of Thunderstorms--30-Hr Fcst

East (Region A)

Predictor	Smoothing (Points)	Valid Time (GMT)	Threshold Value	Cumula-tive RV	Coefficients
TJ TT INDEX	S 9	24	47	.04	-.095
TJ TT INDEX	S 9	24	41	.06	-.019
PE 650 VERT. VEL.	S 9	36	-.0003	.06	.038
PE 850 TMP	S 9	36	288	.07	-.028
SIN DOY	-	-	-.5	.07	-.033
TJ K INDEX	S 9	24	20	.07	-.030
PE 850 TMP	S 9	36	283	.08	-.034
TJ TT INDEX	S 9	24	44	.08	-.028
TJ 850T-850DP	S 9	24	6	.08	-.027
PE MEAN RH	S 9	36	60	.08	-.022
STA LONG	-	-	80	.08	-.021
PE 850 U	S 9	36	4	.08	-.016
CONSTANT					.250

Maximum Probability: .288

Minimum Probability: -.103

Table 3

Probability of Thunderstorms--30-Hr Fcst

West (Region B)

Predictor	Smoothing (Points)	Valid Time (GMT)	Threshold Value	Cumula-tive RV	Coefficients
TJ K INDEX	S9	24	15	.02	-.019
PE 850 TMP	S9	36	288	.03	-.005
TJ CNVCTV INSTAB	S9	24	-10	.04	.062
TJ TT INDEX	S9	24	41	.04	-.020
PE MEAN RH	S9	36	40	.05	-.025
PE G INDEX	S9	36	-2810	.05	.029
STA ELEV	-	-	1800	.05	-.020
PE 850 U	S9	36	0	.05	.017
PE 650 VERT. VEL.	S9	36	0	.05	.015
TJ 700 12NVD	-	24	10	.06	.018
TJ TT INDEX	S9	24	38	.06	-.017
PE G INDEX	S9	24	-2890	.06	.019
CONSTANT					.030

Maximum Probability: .190

Minimum Probability: -.076

Table 4

CONDITIONAL PROBABILITY OF LIQUID PRECIPITATION 30-HR FCST FROM 00Z

Predictor	Smoothing (Points)	Valid Time (GMT)	Threshold Value	Drizzle		Rain		Showers	
				Cumulative RV	Coefficients	Cumulative RV	Coefficients	Cumulative RV	Coefficients
TJ CNVCTV I	S9	24	-3	.00	.010	.12	-.107	.14	.097
PE MEAN RH	S9	36	70	.01	-.080	.15	-.061	.20	.142
PE 850 U	S9	36	4	.02	.077	.17	.087	.23	-.164
COS DOY	--	---	-.5	.02	-.066	.19	-.076	.26	.142
PE 850 TMP	S9	36	283	.03	-.077	.20	.168	.27	-.091
TJ TT INDEX	S9	24	44	.03	.057	.21	.087	.29	-.144
TJ P AMT		24	.00003	.04	-.094	.21	.025	.29	.069
PE P AMT	S9	36	.003	.05	.073	.22	-.125	.29	.052
SIN DOY	--	---	0	.06	-.087	.22	.031	.30	.056
PE BL U	S9	36	-4	.07	-.083	.23	.156	.30	-.074
PE 850 V	S9	36	-4	.07	.002	.24	.141	.30	-.143
STA ELEV	--	---	600	.08	.048	.24	.053	.31	-.100
CONSTANT					.182		.309		.509

Drizzle		Rain		Showers	
Max Probability	.449	Max Probability	1.057	Max Probability	1.067
Min Probability	-.305	Min Probability	-.060	Min Probability	-.207